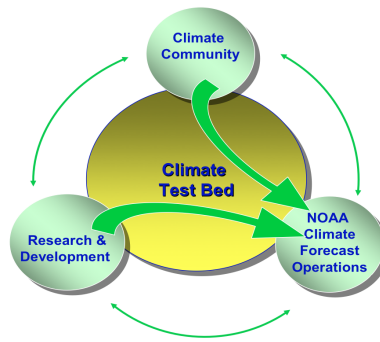# NCEP Climate Test Bed (CTB) Overview

Jin Huang

April 17, 2014
NOAA Testbeds Workshop

Mission: To accelerate the transition of scientific advances from the climate research community to improved NOAA climate forecast products and services.
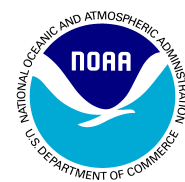
http://www.cpc.ncep.noaa.gov/products/ctb/

Outline

1. **CTB Overview**

2. **Accomplishments and progress**

3. **Performance Metrics/Protocol for CTB R2O Transition and Assessments**

4. **How to make CTB R2O more effective?**

5. **Summary**

NCEP Test Beds

Service – Science Linkage with the Outside Community:
Accelerating the R2O Transition Process

- **EMC**   WRF **Developmental Test Center (DTC)**

  Joint Center for Satellite Data Assimilation

- **CPC**   **Climate Test Bed**

- NHC   Joint Hurricane Test Bed

- HPC   Hydrometeorological Test Bed

- SPC   Hazardous Weather Test Bed with NSSL

- SWPC   Space Weather Prediction Test Bed with AFWA

- AWC   Aviation Weather Test Bed

- OPC   IOOS Supported Test Bed

Organization structure, scope and funding sources are different for different test beds
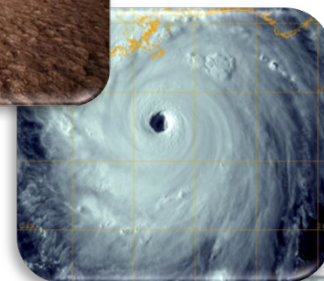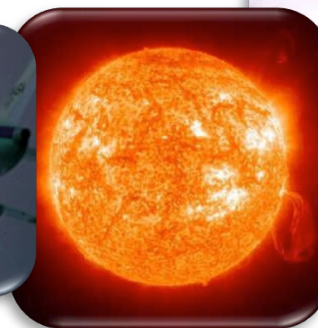
Advancing Operational Climate Prediction and Products
Climate Test Bed (CTB)

- **Jointly established in 2004 by NCEP and CPO**

- **To accelerate R2O transition to improve NCEP operational climate projection**

- **To provide the climate research community with access to operational models, forecast tools and datasets (O2R)**

- **Focus Areas**
    1) *CFS Improvements*
    2) *Multi Model Ensemble (MME)*
    3) *Climate Forecast Products*

- **Competitive grants projects sponsored by OAR/CPO**
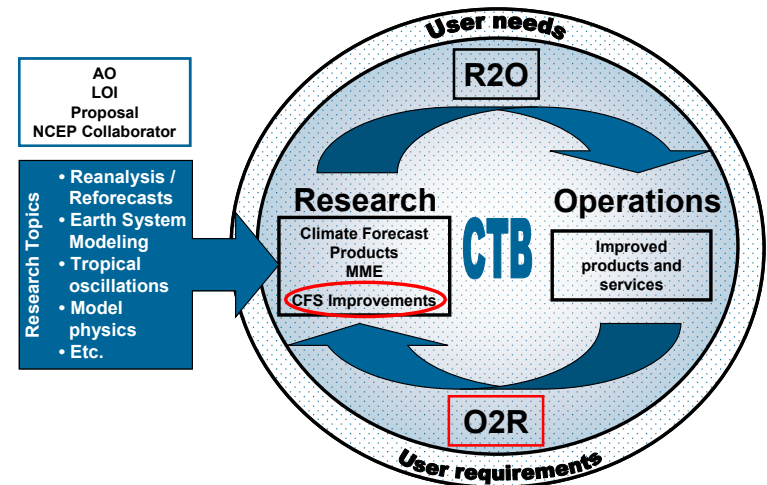
CTB Grants Projects

- **CTB's call for proposals is part of OAR/CPO research program and MAPP-CTB Partnership**

- **CTB priorities in the call for proposals are decided by CPO, mindful of NCEP operational requirements** (via discussions and CTB Science Plan, NWS plans).

- **Currently 3 ongoing CTB grants projects**

- **New FY14 projects are under review.**

Requirements
to Select and Manage MAPP-CTB Projects

- MAPP-CTB proposals must include a section with metrics to be used to evaluate the outcomes of the project and assess readiness for transition into NCEP's operations.

- MAPP-CTB proposals must include co-PIs or collaborators from NCEP.

- MAPP-CTB proposals must include a support letter from NCEP (CTB, CPC and EMC).

- Post-Project Reviews

NCEP Infrastructure Support

Computer resources:

- Proposal based, i.e., no dedicated HPC

FTEs

- One dedicated FTE: CTB director
- Leveraging time from CPC and EMC directors
- Leveraging CPC and EMC FTEs, based on funded projects

CTB Priority (1): Multi-Model Ensembles

Goal: A multi model ensemble prediction system that leverages the best national and international models for improved predictions on intraseasonal-to-interannual time scales

NMME Phase-I: An experimental system initiated as a Climate Test Bed (CTB) research project supported by CPO/MAPP in FY11.

NMME Phase-II: An **improved** experimental system as a FY12-FY13 MAPP/CTB research project with additional support from NSF, DOE and NASA.

NMME Expansion Project in High Impact Weather Prediction Pilot (HIWPP) Project from Sandy Supplemental Fund

NMME (North American Multi-Model Ensemble)

An unprecedented MME system to improve intra-seasonal to interannual (ISI) operational predictions based on the leading US and Canada climate models.
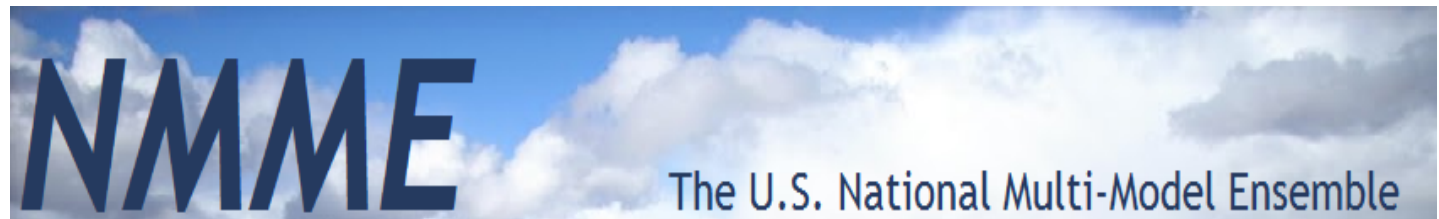
Current NMME Forecast Providers

Model	Hindcast Period	No. of Member	Arrangement of Members	Lead (months)	Model Resolution: Atmosphere	Model Resolution: Ocean	Reference
NCEP-CFSv2	1982-2010	24(20)	4 members (0,6,12,18Z) every 5th day	0-9	T126L64	MOM4 L40 0.25 deg Eq	Saha et al. (2010)
GFDL-CM2.1	1982-2010	10	All 1st of the month 0Z	0-11	2x2.5deg L24	MOM4 L50 0.30 deg Eq	Delworth et al. (2006)
CMC1-CanCM3	1981-2010	10	All 1st of the month 0Z	0-11	CanAM3 T63L31	CanOM4 L40 0.94 deg Eq	Merryfield et al. (2012)
CMC2-CanCM4	1981-2010	10	All 1st of the month 0Z	0-11	CanAM4 T63L35	CanOM4 L40 0.94 deg Eq	Merryfield et al. (2012)
NCAR-CCSM3.0	1982-2010	6	All 1st of the month	0-11	T85L26	POP L40 0.3 deg Eq	Kirtman and Min (2009)
NASA-GEOS5	1981-2010	11	4 members every 5th days; 7 members on the last day of the previous month	0-9	1x1.25deg L72	MOM4 L40 1/4 deg at Eq	Rienecker et al. (2008)

Upcoming new/upgraded models:
- NCAR-CCSM4: May 2014
- GFDL-FLOR: March 2014
- NCAR-CESM1: June 2014

National Weather Service
Climate Prediction Center

Home   Site Map   News   Organization   **Search** [   ] (Go)

HOME > NMME Forecasts of Monthly Climate Anomalies

NMME — The U.S. National Multi-Model Ensemble

Welcome to the National Multi-Model Ensemble home!

NMME real-time seasonal forecast since August 2011 following CPC operational schedules

All participating models strictly follow the NMME protocol and re-run hindcast after model upgrades

-

Data and Current Forecasts

3-month mean spatial anomalies
1-month mean spatial anomalies
Niño3.4 Plumes
International MME
Experimental: Probability forecasts

NMME Realtime Forecasts **Archive**
NMME Phase-I Hindcast Data

About the NMME

Description of the NMME
Phase-I Forecast Models
CTB Activities & Documents
Join the NMME mailing list

NMME Data Available to Users

1. **Realtime forecasts from CPC website**
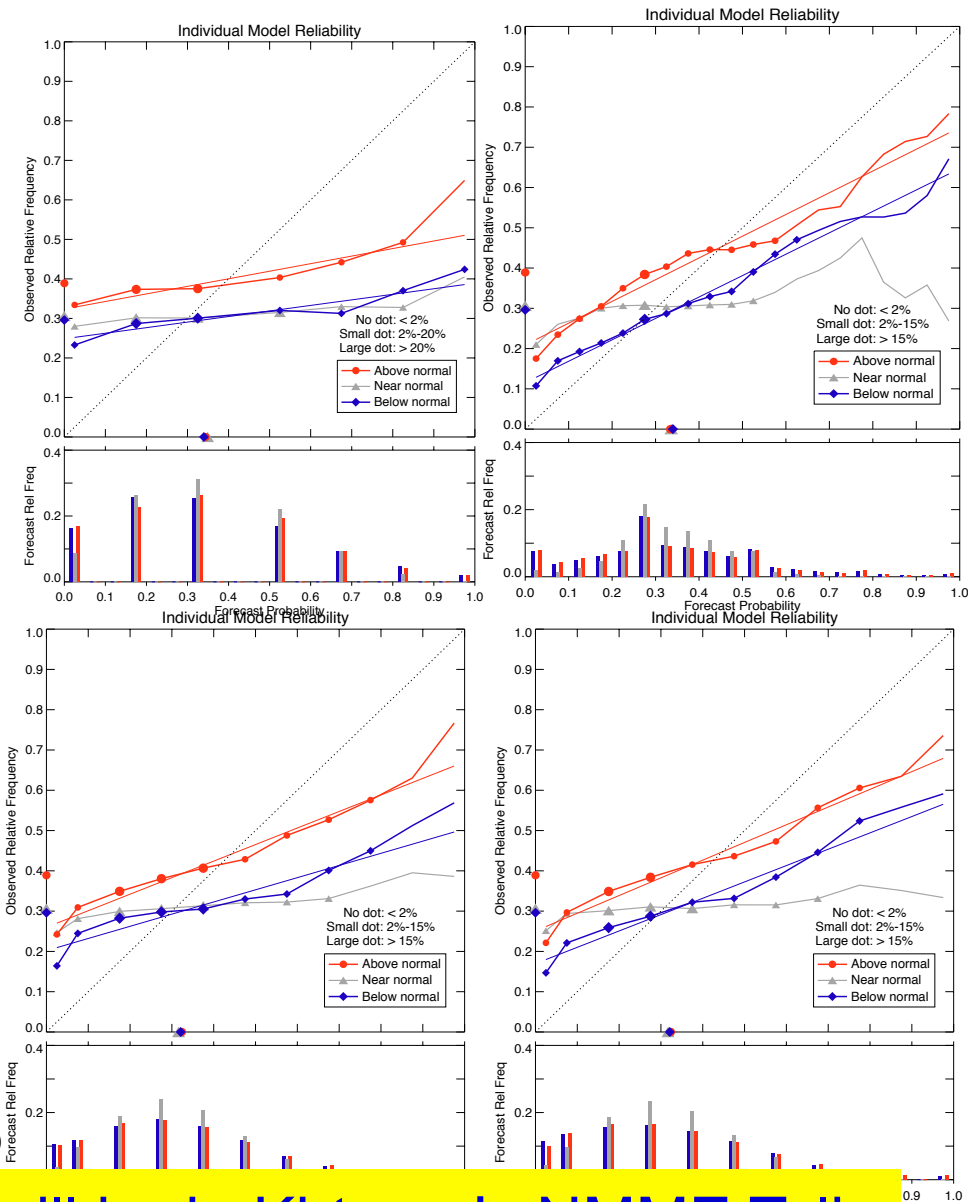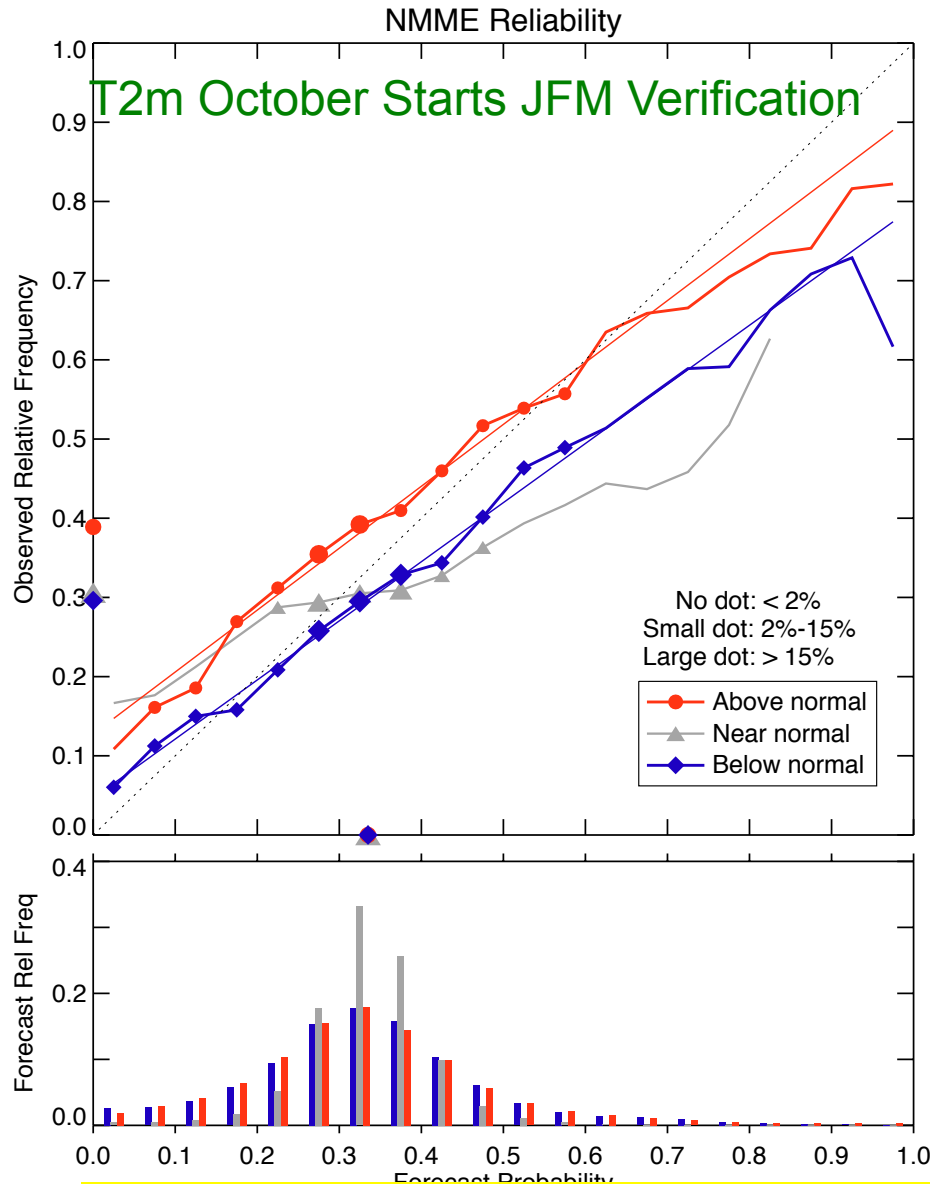   - http://www.cpc.ncep.noaa.gov/products/NMME/

2. **Phase-I Reforecast data in IRI website available now**
   - **Monthly Mean** of 30 year reforecast
   - **8 variables** (P, T, SST, Z200, Tmax, Tmin Soil Moisture, Runoff)
   - http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/

3. **Phase-II Reforecast data in NCAR**
   - Complete monthly Mean of 30 year reforecast
   - Comprehensive daily reforecast data of selected (189) variables
   - https://www.earthsystemgrid.org/search.html?Project=NMME

NMME Increases Forecast Reliability

NMME Reliability

T2m October Starts JFM Verification

No dot: < 2%
Small dot: 2%-15%
Large dot: > 15%

Above normal
Near normal
Below normal

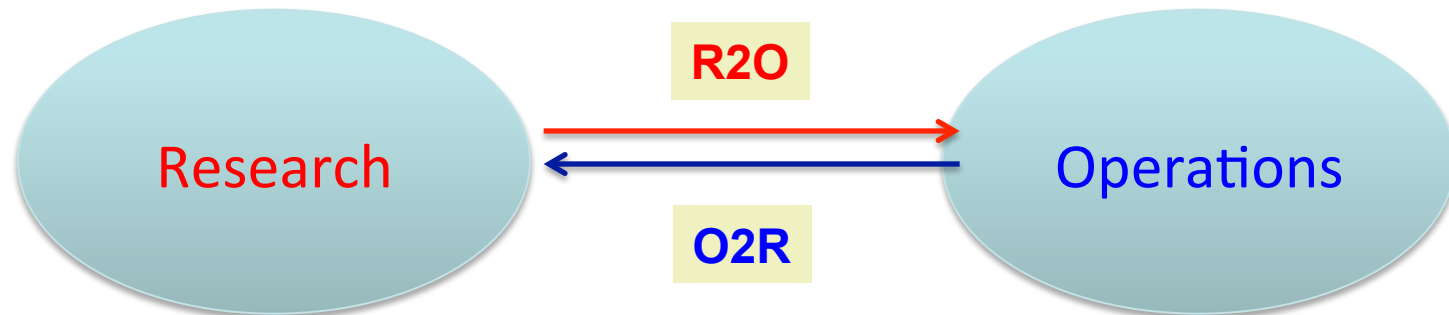Individual Model Reliability

More NMME science results will be in Kirtman's NMME Talk

What Can NMME do for NCEP Operations?

- **R2O to improve NCEP Operation**: NMME allows NCEP to continuously bring in model development advances and expertise from the research community

Research → **R2O** → Operations
Research ← **O2R** ← Operations

O2R to improve research:
- Openly distributed hindcast and real-time data to allow the community to look at climate predictability and predictions;
- Operational platform for model diagnosis and evaluations will also benefit participating research modeling centers.

Strategy to Operationalize NMME Seasonal Forecast System

- **NMME is currently funded as a R2O research project , which will end in July 2014**
  - **Post-project review in Sept. 2014**
  - **CPO plans to fund to sustain the experimental NMME system in FY14**
  - **"Operationalize NMME" has been submitted as a FY15 milestone**
- **Strategy to operationalize NMME**
  - **Concept of Operation has been developed**
  - **Need to i) develop/sign MOUs between operational agencies, ii) secure resources to support non-operational models centers, ii) develop transition path with NCO and CPC regarding data flow, post-processing, and data dissemination**

- **A community-wide NMME workshop early 2015 for future NMME enhancement (e.g., sub-seasonal capability**

CTB Priority (2): CFS Evaluation and Improvements

- **To accelerate evaluation of and improvements to the operational Climate Forecast System (CFS) and to enhance its use as a skillful tool in providing NCEP's climate predictions and applications**

(1) Provide grants funding to support R2O activities

- Test and evaluate new parameterizations, schemes, model components in NCEP operational models

(2) Engage the external community in planning for CFSv3

(3) Provide NCEP in-house support to facilitate R2O

A CPT for Improving Turbulence and Cloud Processes in the NCEP Global Models (FY13-16)

- **U. of Utah: Steven K. Krueger**

- **NCEP: Shrinivas Moorthi and Fanglin Yang**

- **U. of Colorado: Robert Pincus**

- **CSU: David A. Randall**

- **NCAR: Peter A. Bogenschutz**

To unify the representations of
- *turbulence and sub-grid scale cloud processes*
- Sub-grid scale deep convective precipitation and **grid-scale precipitation**

Poster by Moorthi

Cloud and Boundary Layer Climate Process Team (CPT) (FY13-16)

- NCEP: Jongil Han (PI), Ruiyu Sun
- GFDL: Chris Golaz (PI), Ming Zhao
- NASA/JPL: Joao Teixeira (PI), Marcin Witek
- U. Washington: Chris Bretherton (Lead PI), Chris Jones, Peter Blossey

The project is to improve NCEP GFS/CFS:

- Implement a moist Eddy-Diffusion Mass-Flux (EDMF) scheme
- Improve global cloud climatology of GFS+MOM through better cloud microphysical and macrophysical schemes
- Compare GFS-forecast clouds with versions of GFDL climate model run in initialized weather forecast model

Poster by Han

CTB Recent Efforts to Engage the Community in Development of next version CFS

- Organized **CFSv3 Planning Meeting** in August, 2011

- Organized **CFSv2 Evaluation Workshop** in April, 2012

- Developed **a CFSv3 Vision document**

- Coordinated **Special CFSv2 Collection** in Climate Dynamics

- Lead **MAPP Climate Model Development Task Force** with a focus to improve NCEP CFS in 2014-2016

CTB is leading MAPP Climate Modeling Task Force

- Synergize and coordinate with model development at NCEP and OAR labs

- Contribute to the development of the **next-generation operational CFS** via CTB

+40 Participants

- MAPP funded PIs from universities and Gov. agencies
- CTB (Lead)
- NCEP
- NOAA Labs: GFDL, ESRL
- COLA

NCEP in-house Support is needed to Facilitate R2O

- Recognized that NCEP cannot afford a community model, e.g., NCAR/CCSM.

However,

- External visitors and collaborators need NCEP O2R support to facilitate collaborations, e.g.,

  o More accessible model codes/scripts, documentation, experimental data

  o User technical support

  o Verification metrics and database

  => Model Test Facility?

CTB Priority (3): Improving Climate Forecast Tools/Products

Goal: **To provide reliable climate forecast products that are responsive to the needs of users and incorporate state-of-the-art science and research**
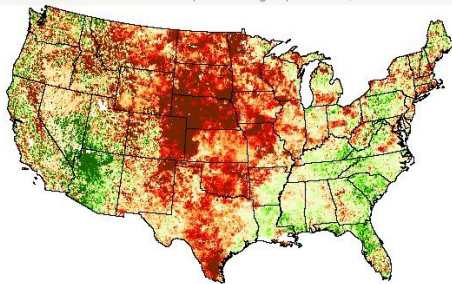
Evaporative Stress Index (**Anderson, FY10**)

NMME-based drought forecast (after Kintse Mo)
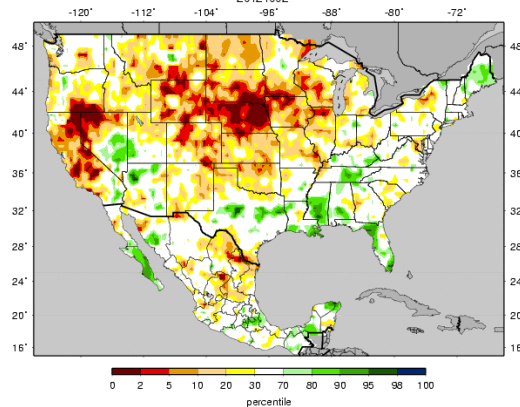
Enhancing operational drought monitoring and prediction products **(Lettenmaier, Wood and Mo, FY10)**
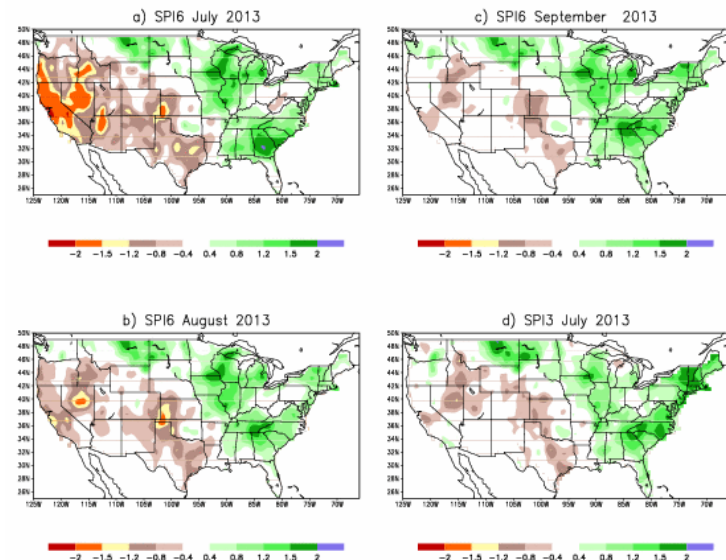
Princeton University's Hydrologic Forecast Methodology
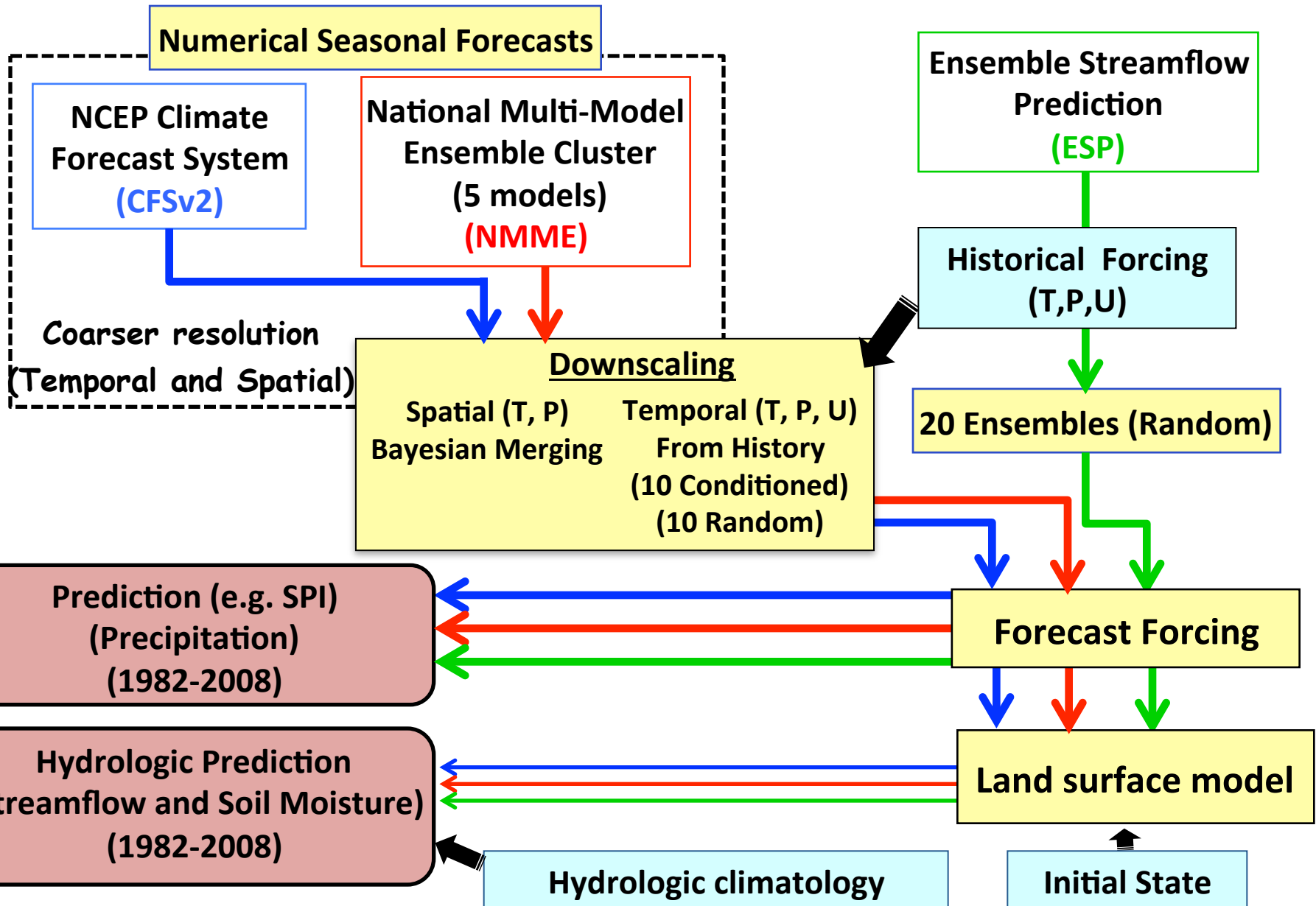
Progress has been made to develop Performance Metrics/Protocol for CTB R2O Transition and Assessments

1. **Metrics for Climate Model Evaluations**

2. **Climate Forecast Evaluation Metrics and Protocol**

3. **Metrics and Protocol for Assessment of Drought Monitoring and Forecasting Capabilities**

Assessing
Drought Monitoring and Prediction Capabilities

CTB is leading the MAPP Drought Task Force Research to Capability (RtC) Assessment Effort.

- **Dedicated evaluation efforts are needed for building baseline systematic assessments**

Key predictand (s) for drought variable (e.g., P, T, soil moisture, streamflow)	Metric(s) and skill scores comparing
Onset and recovery of drought condition	Lead time of prediction Error of identification
Duration and severity of drought condition	Error, bias, correlation (time, value)
Indication (detection, prediction) of drought condition: deterministic	Categorical metrics: Critical Success Index (CSI), Equitable Threat Score (ETC) Probability of Detection (POD), False Alarm Rate (FAR), and others.
Probability of drought condition: probabilistic	Brier Skill Score (binary); secondarily, Brier decompositions for reliability and resolution
Value, overall Value given drought occurring in the observed or forecast period	1. Error, bias, correlation (of ensemble mean or median for probabilistic) 2. Ranked Probability Score (CRPS)

Development of MAPP Drought Assessment Protocol

- Guidance for CPO/MAPP PIs to address the benefits of research

- Assessment metrics for drought monitor and forecast

- Verification data

- Verification period and case studies

- Baselines and benchmarking

NCEP Metrics for Climate Model Evaluations
(to be discussed/improved during CFSv3 development)

- **AMIP and CMIP Simulations Diagnosis:**
  - Mean bias (surface temperature; precipitation; T, u, v in the free atmosphere)
  - Modes of variability (PNA, NAO,...)
  - MJO; wind shear in Atlantic
  - ENSO tele-connection

- **Initialized predictions**
  - **Weather forecasts**:   using EMC Verification Package
    - Anomaly correlations, biases, RMSE (u, v, T, P, SLP, q, cloud)
    - hurricane track and intensity errors

  - **ISI time forecas**t: P, T and ENSO forecast skills.

Climate Forecast Evaluation Metrics and Protocol

Forecast Evaluation Protocol for monthly/seasonal forecasts (following NMME Protocol):

Hindcast period:
- minimum 30 years (1982-2012)

Forecast lead time:
- 1- 9 months

Number of ensemble members:
- To be decided by the tool developer

Basic data:
- Monthly mean of T2m, Prate, Z200 and SST

Data requirements:
- Include each ensemble member and total uncorrected fields.
- Data format: Grid 1x1
- Domain: Global

Metrics:

Deterministic/Continuous :
- Anomaly Correlation (AC)
- Root Mean Square Error (RMSE)
- Mean Absolute Error
- Amplitude
- Biases
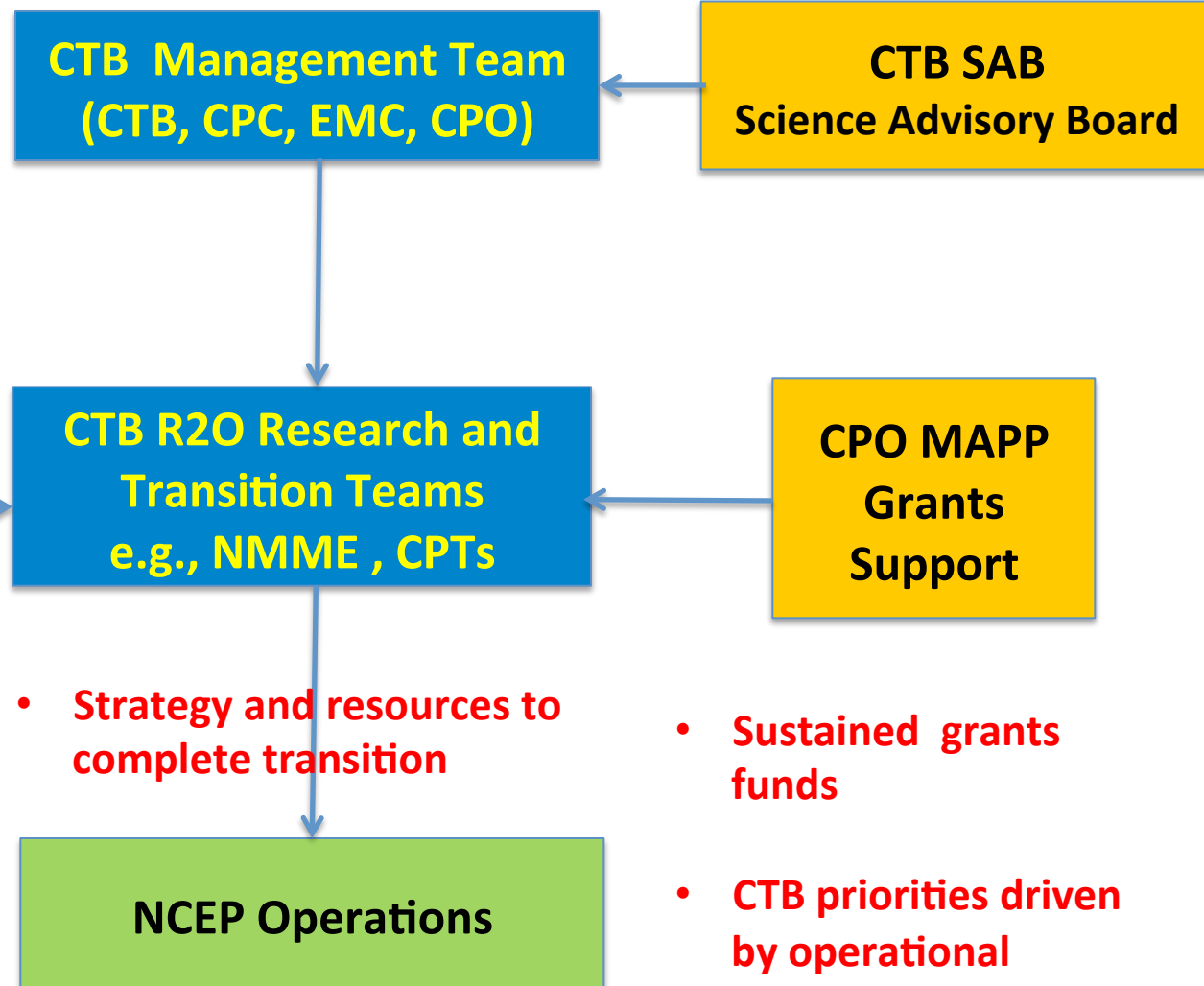
Categorical:
- Contingency Table
- Heidke Skill Score

Probabilistic:
- Brier Skill Score (BSS)
- Rank Probability Skill Score (RPSS)
- Reliability

- Metrics could also be applied to existing operational tools/models for upgrades or phasing-out.

How to Make CTB Viable and Effective?

- **A formal management approach above and beyond the CTB director to identify priorities and resources for CTB Activities**

CTB Management Team (CTB, CPC, EMC, CPO)

CTB SAB Science Advisory Board

NCEP In-House Support (FTEs, HPC)

CTB R2O Research and Transition Teams e.g., NMME , CPTs

CPO MAPP Grants Support

- **Committed NCEP in-house O2R support**

- **Strategy and resources to complete transition**

- **Sustained grants funds**

NCEP Operations

- **CTB priorities driven by operational requirements**

Summary

- **CTB is aimed at accelerating transitioning science advances to improved NOAA climate operations.**

- **CTB is jointly sponsored by CPO grants program and NCEP infrastrucuture (FTE, HPC) support**

- **CTB has contributed to NCEP operations**
  1) *CFS evaluations and improvements*
  2) *Multi-model ensembles*
  3) *Climate forecast tools and products*

- **Challenges/requirements for more effective R2O**
  o **A formal management approach above and beyond the control of the CTB director to identify priorities and resources for CTB R2O activities.**
  o **Sustained grants support for R2O projects** driven by NCEP operational requirements
  o **Committed NCEP O2R support** to facilitate external collaborations
  o **Resources to complete R2O transition** after CTB R2O project is completed.